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PYRETHROID-TREATED JACKETS VERSUS REPELLENT-TREATED JACKETS AND HOODS FOR PERSONAL PROTECTION AGAINST BITING FLIES

by

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ABSTRACT

In this report, the concept of using wide-mesh jackets treated with an insecticide rather than a "space" repellent compound for protection against biting flies is examined. This concept, first studied by the USDA Laboratory at Gainesville, Florida, is based on the hypothesis that reduction in the insect population in the vicinity of a jacket through insecticidal action would be sufficient to provide effective personal protection for the wearer.

Small field tests were carried out at Canadian Forces Base Petawawa to compare the effectiveness of jackets treated with permethrin insecticide, a rapid insect-knockdown compound, the standard repellent N,N-diethyl-m-toluamide (deet), and the experimental repellent tetrahydrofurfuryl octanoate. The ability of repellent-treated wide-mesh hoods to provide facial protection against mosquitoes and blackflies was also investigated.

RESUME

Dans ce rapport, on compare les avantages des survêtements en filet à grandes mailles imprégnés d'un insecticide, à ceux d'un insectifuge à vaporiser, pour éloigner les mouches piqueuses. Cette méthode, qui a d'abord été mise à l'essai au laboratoire de l'U.S.D.A., à Gainesville (Floride), repose sur l'hypothèse selon laquelle l'action insecticide de ce type de survêtement est suffisante pour diminuer le nombre d'insectes dans l'espace immédiat de celui qui le porte et ainsi lui assurer une protection contre les insectes.

Des essais à échelle réduite ont été effectués en conditions réelles d'utilisation, à la base des Forces canadiennes de Petawawa, afin de comparer l'efficacité des survêtements imprégnés de perméthrine, qui est un insecticide à action instantanée, avec celle du diéthyl-m-toluamide (deet) et de l'octanoate de tétrahydrofurfuryle qui sont respectivement un insectifuge d'utilisation courante et un insectifuge experimental. On a aussi étudié l'efficacite d'un voile en filet à grandes mailles, imprégné d'un insectifuge et destiné à éloigner des moustiques et les mouches noires de la région faciale.

INTRODUCTION

Extensive testing in different countries under a variety of conditions has established that repellent-treated, wide-mesh jackets provide effective personal protection against biting flies (1-6). These garments, originally developed by the US Navy Medical Field Research Laboratory (NMFRL), are constructed from lightweight polyester netting for strength and cotton strands to absorb the repellent. They take the form of a waist-length jacket with a hood which covers the head but not the face (Figure 1).

The jackets are impregnated with a "space repellent", a chemical which affects biting insects in the vapor phase although direct contact with the treated surface can also produce repellent action. Each jacket is packed in a small plastic pouch with a two-fluid-ounce bottle of repellent. Prior to wearing, the user may impregnate the jacket by wetting it with repellent and sealing it in the pouch for about twelve hours after which the garment may be worn. When treated with a highly effective repellent, for example N,N-diethyl-m-toluamide (deet), the jacket can provide protection against mosquitoes, blackflies and other biting flies for periods of six weeks or longer in daily use (depending upon climatic variables, activities of the wearer, etc.) provided it is kept in its plastic pouch when not being worn (1,5). Disadvantages of the treated jackets include a flammability hazard (6) and a restriction on the mobility of the wearer when moving through brush due to snagging. When holes or snags occur in the jacket fabric, the protection provided against biting flies is not impaired (3, 5, 6).

Generally, the Canadian Forces standard repellent diethyl-m-toluamide (deet) is used as a jacket treatment, although several other repellents have been investigated for garment application (2, 3, 4). A list of candidate repellents which can replace deet, should the need arise, has been compiled (7). The spatial action of repellents is believed to extend only a few inches from the treated surface and, in contrast to insecticides, repellents do not reduce the insect population in the vicinity of the treated surface.

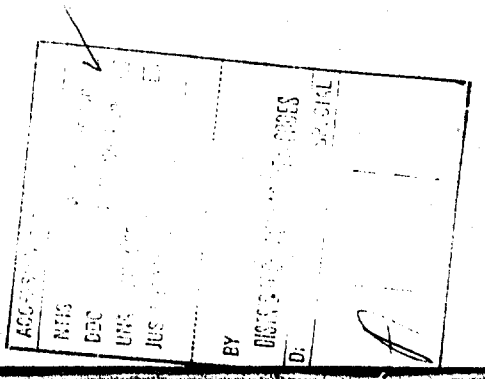

Figure 1. Subject Wearing Insect-Repellent Jacket

Another means of providing protection for personnel against biting flies is through the use of insecticides, applied to a land area as an aerosol spray or fog. In this type of application, the natural pyrethrins and related synthetic derivatives (pyrethroids) are generally potent insecticides while, at the same time, they are biodegradable and of low mammalian toxicity (8). They can be used to control a wide variety of insects, either by contact or as stomach poisons, and often have quick-knockdown characteristics. One of the most promising pyrethroids is permethrin, a compound which combines the desirable features of high potency against insects at low concentration, stability in air and light for an acceptable period and extremely low mammalian toxicity (8, 9).

Recently, preliminary tests conducted by the USDA Laboratory at Gainesville, Florida indicated that wide-mesh jackets treated with a pyrethroid compound can offer protection against biting flies through insecticidal action (10). The effect of the treatment was to reduce the insect population in close proximity to personnel wearing the treated jackets to acceptable levels. The level and duration of reduced insect population depended upon a number of variables including area insect population pressure, number of personnel wearing treated jackets, movement of personnel, etc. (10). The USDA tests also indicated that the insect reduction was such that individuals who were in close proximity to personnel wearing treated jackets were also protected. The amount of pyrethroid applied to the jackets for these tests was very small.

In this report, an evaluation of insecticide-treated jackets to determine their protective properties against some Canadian species of biting flies, both mosquitoes and blackflies, is described.

Field tests were conducted at Canadian Forces Base Petawawa, Petawawa, Ontario, to compare the effectiveness of jackets treated with the pyrethroid permethrin, and jackets treated with the standard repellent deet. Of the pyrethroids available, permethrin was chosen for use as a jacket treatment since this compound is highly active against many insect species and is one of the most stable pyrethroids under typical conditions of exposure to air and light in the field (8).

In addition, an evaluation was carried out to determine whether a repellent-treated hood constructed of the wide-mesh material could provide as much facial protection as the complete repellent-treated jacket and hood. In the military context, the use of a hood alone offered several potential advantages over the jacket ensemble such as economy, reduction in snagging when moving through dense brush, less bulk and weight, less repellent required, reduction in flammability hazard, ease of storage, etc. Jackets treated with the compound tetrahydrofurfuryl octanoate (THFO), a promising experimental repellent, were also tested.

MATERIALS AND METHODS

Chemicals

N,N-diethyl-m-toluamide (deet) was procured as a 75% solution in isopropanol[a] and was used without further purification. Permethrin (±-cis,trans-NRDC-143) was obtained from Chipman Chemical Ltd. in solid form, 93.9% purity, and used without further purification. Tetrahydrofurfuryl octanoate (THFO) was synthesized by reaction of tetrahydrofurfuryl alcohol with octanoyl chloride using triethylamine as acid scavanger and purifying the product by fractional distillation under reduced pressure. The product obtained was a clear, pale yellow oil, bp_1 127-131°C, n_D^{25} 1.4438.

Jackets and Hoods

A number of jackets were constructed[b], weighed and then, in the case of deet or THFO, treated at the rate of 0.25 g of repellent per gram of netting (as recommended by NMFRL) by immersing them in appropriate repellent/isopropanol solutions or with permethrin at the rate of 0.07 g per gram of netting by immersing the garments in an acetone solution of the insecticide.

Hoods were constructed from the same mesh material used in the jackets and followed the same design as those which were an integral part of the jacket ensemble. In addition, a neck flap approximately 8 cm wide was sewn around the lower portion of the hood and all edges of the netting were trimmed with a close-weave nylon strip (Figure 2). The hoods were weighed and treated at the rate of 0.25 g of deet per gram of netting.

Following treatment, the jackets and hoods were air dried overnight to permit evaporation of solvent and then all items were stored separately in foil-lined paper bags until used. Several untreated jackets complete with hoods were used as control items during the field evaluations.

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[a] This solution is the standard issue repellent for Canadian Armed Forces personnel.

[b] Using S-1624 jacket netting, Polylox Corp., New York, N.Y.

Figure 2. Subject Wearing Repellent-Treated Hood

Conduct of Field Evaluations

The jacket, hood and repellent evaluations were carried out at CFB Petawawa, Petawawa, Ontario during the last week in May and the first week in June, 1977. Test sites were selected at different locations on the base; all sites were heavily wooded and located near to a lake, stream or swampy area. Figure 3 shows the site near Half Mile Lake. Other sites included the Montgomery Lake area and streams located near Brindle Creek Road and Orange Road.

Weather conditions during testing were variable, ranging from hot and dry to cool and wet. Temperatures ranged between 18°C and 24°C and relative humidities ranged between 40% and 90%. Tests were usually carried out during the morning or evening hours when the insects were most active.

All test sites contained mixed populations of blackflies and mosquitoes with blackflies usually predominating. Small numbers of tabanidae (deer flies, horseflies) were also observed in the Orange Road area.

During testing, the jackets were worn over dark green coveralls with the hood drawn up over the head and sleeves covering the arms to the wrist area. In evaluating the jackets, the number of insect landings which occurred on the face was considered more indicative of the relative effectiveness of individual items; data for landings which occurred on the hands or on the front of the jackets have been included in the report for reference purposes. When testing permethrin-treated jackets, subjects recorded landings in the facial area and on the front portion of the jacket from neck to waist but excluding the sleeves. When separate hoods were undergoing tests, they were worn in the same configuration as the hoods of the jacket ensembles. In these tests, the hands of subjects were left unprotected to give an indication of whether any long-range protection for the hands was being offered by the hoods.

Six men were used as subjects for each test. During evaluations, at least two and sometimes three of these subjects acted as controls by wearing untreated jackets. Tests were conducted for a period sufficient to accumulate a relatively large number of control and test landing counts. During the course of a test, control subjects and test subjects exchanged garments after sufficient data had been accumulated; control subjects donned test items which other subjects had been wearing, while the latter changed into clean coveralls and donned untreated jackets. Following this exchange, landing counts were taken for another period. Care was taken to ensure that each test item and subject was exposed to the biting-fly population for the same length of time.

When testing permethrin-treated jackets, landing counts were recorded for consecutive 10-minute periods to indicate if the rate at which insects were landing was changing due to population decrease from the insecticidal action of the jacket treatment. Control subjects were located at least 50 metres from those subjects wearing permethrin-treated jackets to avoid the possibility of control landing counts being affected by the treatment's insecticidal action.

A typical test followed the routine described below:

1) Subjects were transported to a site and were issued appropriate test items;

2) The subjects sat in prearranged pairs for a period of time and each subject recorded the number of insect landings which occurred on the face and hands of his partner using two hand-held counters (Figure 4). A landing was defined as one in which an insect alighted and began to probe or bite. When testing permethrin-treated jackets, landing counts were taken on the face and front portion of the jacket from neck to waist but excluding the sleeves.

3) A rotation of subject pairing occurred, along with an exchange of control and test items, as described previously. This exchange was followed by a second session of sitting in pairs and recording insect landings.

4) During each test, measurement of ambient conditions was carried out using a sling psychrometer and anemometer to give data on dry-bulb temperature, relative humidity and wind speed. Insect specimens which landed on subjects were collected using an aspirator.

5) At the conclusion of the test, all equipment was collected and the subjects were transported from the site.

Tests Involving Permethrin-Treated Jackets

To indicate whether permethrin-treated jackets could provide satisfactory protection against biting flies, an initial test was carried out at the Half Mile Lake site. Two control subjects recorded landings at a location well-removed from where four others, each wearing a treated jacket, took landing counts. In addition, two of these four subjects recorded landings for consecutive 10-minute periods to gain preliminary information

Figure 1. Soldiers securing vessel landings

on whether the insecticidal action of the jacket treatment was affecting the insect population density during the test period.

A second test was carried out at Montgomery Lake where all subject pairs recorded landings on the front of the jackets for consecutive 10-minute periods. The two control subjects wore headnets and gloves to protect their faces and hands. The four subjects wearing permethrin-treated jackets were grouped into two widely separated pairs; these subjects did not wear gloves on their hands or wear headnets.

The data from both tests were combined and average landing counts per subject wearing permethrin-treated jackets or untreated jackets were calculated. In addition, landing counts per subject were averaged over each 10-minute recording period to determine whether a change in insect landing rates was occurring during the course of testing.

Comparison of Jackets Treated With Permethrin and Deet

A test was carried out at the Orange Road site to compare the effectiveness of permethrin-treated and deet-treated jackets against biting flies. Pairs of subjects wore either untreated jackets (controls) or jackets treated with permethrin or deet. Pairings were such as to group those two subjects wearing identical items together, with the pair wearing permethrin-treated jackets located well away from the other subjects. Landing counts were taken on the face and front portion of the jacket.

Evaluation of Repellent-Treated Jackets and Hoods

Tests near a stream on Brindle Creek Road and also at Half-Mile Lake were carried out to determine the relative effectiveness of jackets treated with either deet or THFO and of hoods treated with deet. In each case, a subject wearing one of the three types of test items was paired with a control subject wearing an untreated jacket. Following a period of recording landing counts on the face and hands, each control subject donned a test item, usually a different type than the one monitored previously, while their partners removed their test items, changed into clean coveralls and donned an untreated jacket. Further landing counts on the face and hands were then recorded. This procedure was repeated several times so that at the conclusion of the evaluation, each subject had tested all of the available test items at least once and had acted as a control several times.

RESULTS

Permethrin-Treated Jackets

During the course of testing, approximately 75% of the recorded landing counts were blackflies and the remainder were mosquitoes. The species of biting flies collected on subjects during testing are listed in Appendix A.

The combined data from tests at two different l tions indicate that the permethrin-treated jackets reduced substantially the number of insect landings in the facial area and on the jacket front as compared to untreated jackets (Table I). An "effectiveness rating" was assigned to these items using the following formula:

$$\text{Effectiveness Rating} = \frac{N_c - N_i}{N_c} \times 100$$

where N_c = average landing count per control subject,

and

N_i = average landing count per subject wearing treated item.

TABLE I

Effectiveness of Permethrin-Treated Jackets

Treatment	Average Landing Counts Per Subject			Effectiveness Rating	
	Face	Jacket Front	Total	Face	Total
Permethrin	34	42	76	81	83
None[c]	182	269	451	0	0

[c] untreated jacket (control)

It was noted that the landing counts for those subjects wearing permethrin-treated jackets began to drop rapidly following the first 10 minutes of each test. Several blackflies which had contacted the jacket were observed to fall to the ground and undergo leg and wing spasms indicative of insecticidal poisoning.

As illustrated in Figure 5 using data from the test carried out at Montgomery Lake, the average landing count for a subject wearing a permethrin-treated jacket was initially high but decreased rapidly following the first 10 or 20 minutes. As expected, the average landing count for a control subject varied with the insect population density in that given area over each 10-minute period.

Relative Effectiveness of Permethrin- and Deet-Treated Jackets

Using data for the entire test period, the results in Table II indicate that the deet-treated jackets are more effective than the permethrin-treated jackets in protecting personnel against biting flies. Again, a high proportion of the landing counts for those subjects wearing permethrin-treated jackets occurred during the first 10 to 20 minutes of the test, followed by much lower counts. The difference in protection afforded the face by the two types of jackets was found to be significant (5% significance level) using a chi-square analysis test (11) (see Appendix B).

TABLE II

Effectiveness of Permethrin- and Deet-Treated Jackets

Jacket Treatment	Average Landing Counts Per Subject			Effectiveness Rating	
	Face	Jacket Front	Total	Face	Total
Deet	13	35	48	91	83
permethrin	32	46	78	78	73
None (control)	137	152	289	0	0

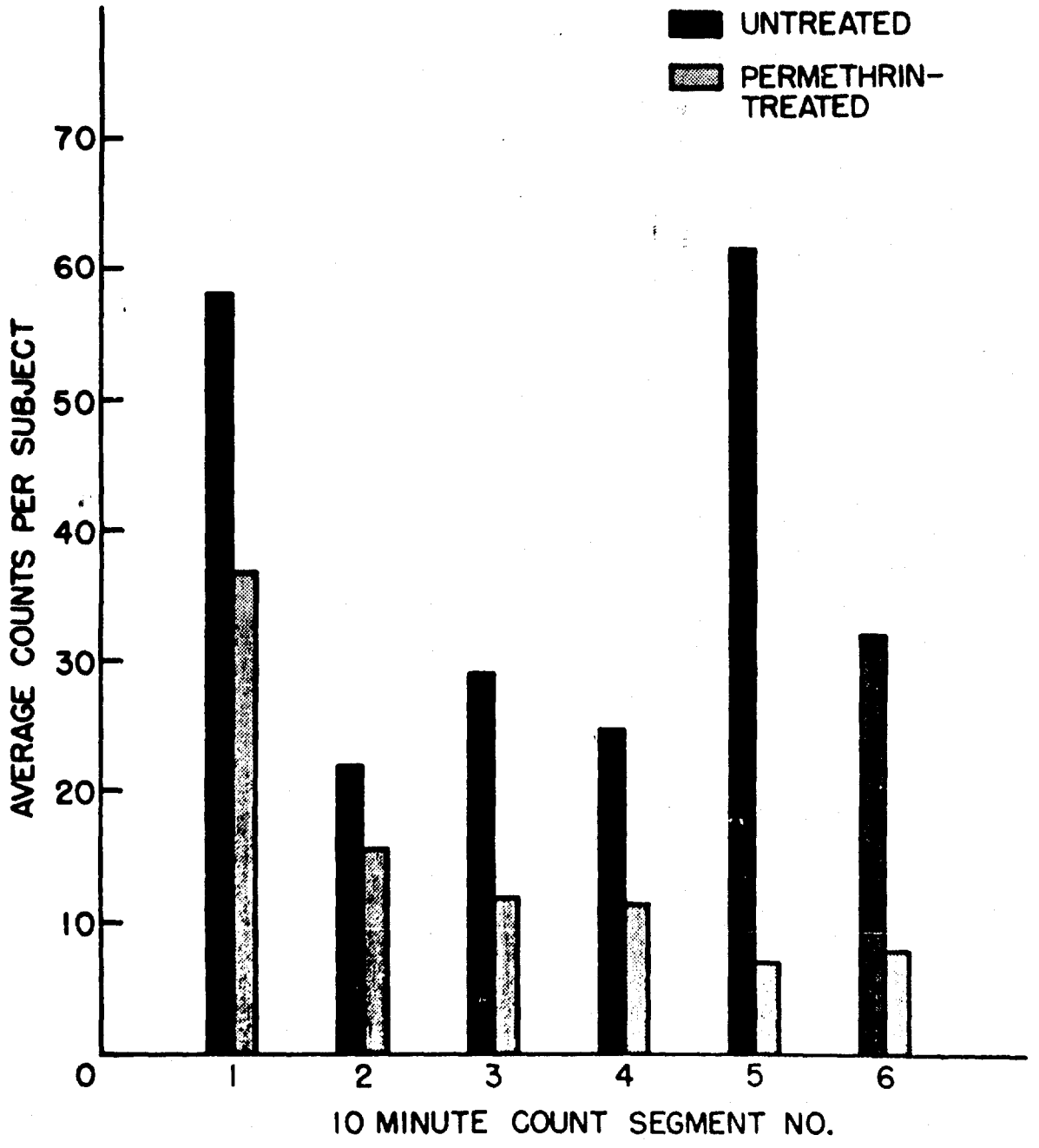

Figure 1. Landing Counts on Front of Jacket for Consecutive 10 Minute Periods.

Comparative Tests of Repellent-Treated Jackets and Hoods

The combined results from two separate tests carried out at the Brindle Creek Road and Half Mile Lake sites are given in Table III.

TABLE III

Effectiveness of Repellent-Treated Test Items

Item	Treatment	Average Landing Counts Per Subject			Effectiveness Rating	
		Face	Hands	Total	Face	Hands
Jacket	THFO	13	67	80	92	83
Hood	Deet	17	398	415	90	1
Jacket	Deet	24	104	128	85	74
Jacket	none	164	403	567	0	0

One of two deet-treated jackets tested contained two openings in the front of the garment, approximately 6 cm in diameter, to permit access to front pockets on undergarments. No significant difference in the average count rates per subject was found for this jacket and its counterpart which contained no front openings.

The results in Table III indicate that all items tested were effective in protecting the facial area and, with respect to the treated jackets, the hands were protected to a large extent as well. As expected, the deet-treated hood by itself did not protect the hands against biting flies. A chi-square analysis of the data in Table III indicated no significant difference ($P = 0.05$) in the level of protection provided to the facial area by the two treated jackets and the hood. (See Appendix B).

DISCUSSION

The results using averaged landing-count data indicate that jackets treated with the repellent deet are somewhat more effective than jackets treated with the insecticide permethrin in protecting

personnel against biting flies, particularly in the case of facial protection. However, for individuals wearing permethrin-treated jackets, the majority of landing counts occurred during initial exposure to the biting-fly population before the insecticidal action of the treatment had reduced substantially the number of insects in the immediate vicinity of the wearer. Once a degree of "area" control of the insect population had been achieved (10 to 20 minutes following initial exposure), the permethrin-treated garments protected the face and body area very effectively, especially in cases where two or more individuals wearing the garments were in a small area.

From the data for the test carried out at Montgomery Lake (see Figure 5), it was noted that the calculated effectiveness rating of the permethrin-treated jackets (using data for landings on the jacket front) was somewhat lower (rating = 61) than in other tests involving these garments. This difference may be a result of the fact that the control subjects in this experiment wore headnets and gloves, thereby reducing their overall attractiveness to biting flies, while subjects wearing treated jackets had their hands and faces fully exposed to the insect population. Thus, the control subjects may not have experienced as high a landing rate on their jacket fronts compared to the case where their faces and hands were unprotected.

The distance over which a jacket treated with permethrin is effective was not determined during testing. It was noted that unprotected individuals not involved in the testing, e.g., vehicle drivers, commented on several occasions that they were no longer being bothered by biting flies when they stood within a few feet of a subject wearing a treated jacket.

Several advantages of insecticide-treated jackets over repellent-treated jackets became apparent during the evaluations. Aside from the possibility that a few individuals wearing insecticide-treated jackets might provide "area" protection for other personnel, the relatively small amount of chemical used in the jacket produced little odour and left the jacket material with a natural, non-greasy feel. Re-treating jackets in the field with pyrethroid insecticide, although not carried out during the tests, was deemed not to be a problem. As in the case of retreatment using repellents, jackets could be soaked in a dilute solution of chemical dispensed from a two-fluid-ounce bottle.

For situations requiring personnel to remain in fixed locations for relatively long periods of time, for example, sentry duty or reconnaissance posts, pyrethroid-treated jackets with little or no distinctive odour associated with them may offer an alternative to repellent-treated jackets or applying liquid repellent to the skin for biting fly protection. Once the insect population in a given location is reduced through exposure to the jacket treatment, a few individuals wearing jackets may provide

sufficient protection for all other personnel. The protective period would depend on the size of the affected area and the insect pressures beyond it. In mobile situations, pyrethroid-treated jackets would not be expected to be as effective as repellent-treated garments because of their delayed action compared with e.g., deet-treated jackets. This problem might be overcome by (a) using more pyrethroid on the jackets than at present which might offset the advantages of little odour, (b) by the use of synergists with the pyrethroid treatment which might shorten insect knockdown and kill times; or (c) by adding a small quantity of deet to the pyrethroid treatment to provide enhanced initial protection. Further work on all three points is necessary to establish whether these approaches can improve the initial and longer-term protection afforded by pyrethroid-treated garments.

Under the test conditions, hoods treated with deet were found to be as effective as repellent-treated jackets in providing facial protection. As stated, hoods offer advantages over the jacket ensemble, such as increasing the mobility of the wearer by reduction of snagging, lower flammability hazard, reducing the amount of weight carried, ease of storage and economics. In situations where an individual's clothing provides adequate biting-fly protection for the body, wearing a repellent-treated hood and applying repellent to the hands appears to be a practical system, especially for personnel who don't mind applying repellent to the hands but are averse to applying it to the face every few hours. The Canadian Forces repellent which is issued in a two-fluid-ounce container would serve both purposes; that is, for applying liquid repellent solution to the hands and for treating the wide-mesh hood material when required.

The results of testing indicate that tetrahydrofurfuryl octanoate as a jacket treatment is as effective as deet in protecting personnel against biting flies. The compound is easily synthesized from relatively inexpensive and readily available starting materials. Prior work (14) has shown that tetrahydrofurfuryl octanoate is highly effective as a clothing repellent against several mosquito and tabanid species.

CONCLUSIONS

Under the given conditions, the following conclusions were drawn from the field evaluation results:

1. Jackets treated with the insecticide permethrin provided personnel with good protection against biting flies but, based on overall landing counts, were not as effective as jackets treated with deet, especially for protecting the face during initial exposure to the biting fly population.

2. The insecticidal action of permethrin-treated jackets reduced the biting fly population in the vicinity of the jacket to much lower levels after approximately 10 minutes exposure after which effective protection was afforded.

3. Both blackfly and mosquito adults were affected by the permethrin treatment.

4. When using permethrin as a jacket impregnant, the amount of chemical required to provide good protection is less than one-third that required when using deet or other repellents.

5. Wide-mesh hoods treated with deet were as effective as jackets treated with deet or tetrahydrofurfuryl octanoate in providing protection to the facial area.

6. Tetrahydrofurfuryl octanoate is as effective as deet as a jacket treatment for biting fly protection.

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APPENDIX A

The following biting-fly adults were collected at CFB Petawawa during the course of testing from 30 May to 3 June, 1977. The majority of specimens were collected at the Half Mile Lake and Montgomery Lake sites.

1. Blackflies (Simuliidae)

   Simulium venustum (Say)
   Simulium decorum (Wlk)

2. Mosquitoes (Culicidae)

   Mansonia perturbans (Wlk)
   Aedes cinereus (Mg)
   Aedes intrudens (Dyar)
   Aedes sticticus (Mg)
   Aedes punctor (Kirby)
   Aedes vexans (Mg)
   Aedes canadensis (Theob)
   Aedes stimulans (Wlk)

APPENDIX B

Chi-Square Analysis of Landing-Rate Data

The chi-square test was used to determine whether differences in the average landing counts per subject between various treated jackets or treated hoods were significant. Contingency tables (2 x 2) were constructed using the effectiveness ratings shown in Tables II and III. The null hypothesis tested in all comparisons was that no difference existed between the items in the level of protection provided. The 5% level of significance was chosen (P = 0.05) with a correspondingly tabulated value of χ^2 of 3.84, for one degree of freedom (12). Calculated values of χ^2 greater than 3.84, therefore, signalled rejection of the hypothesis, while those less than this number indicated no significant difference between the items being compared. The contingency table for the comparison of the deet- and permethrin-treated jackets is shown below. The effectiveness rating data for the face is used in this example.

Jacket Treatment	Effective	Non-Effectiv	Total
deet	91	9	100
permethrin	78	22	100
Total	169	31	200

The Yates correction for 2 x 2 tables (which improves the chi-square approximation for the 2 x 2 table and for low frequencies) was employed in all cases. In this example the table becomes:

Jacket Treatment	Effective	Non-Effective	Total
deet	90.5	9.5	100
permethrin	78.5	21.5	100
Total	169	31	200

Using the simplified formula for a 2 x 2 table (13), χ^2 was calculated as follows:

$$\chi^2 = \frac{n\,(a'd' - b'c')^2}{(a+b)(a+c)(c+d)(b+d)}$$

$$= \frac{200\,[(90.5)(21.5) - (9.5(78.5)]^2}{(100)(169)(100)(31)}$$

$$= 5.50$$

Since the calculated vlaue of χ^2 is greater than 3.84 (P = 0.05), it is concluded that the deet-treated and permethrin-treated jackets are significantly different as far as protecting the facial area is concerned. The results for other comparisons are shown in the following table.

Calculated Chi-Square Values

Comparison	Landing Data	χ^2	Significant difference
deet/permethrin jackets	Table II (face)	5.50	yes
deet/permethrin jackets	Table II (total)	3.57	no
THFO/deet jackets	Table III (face)	1.77	no
THFO/deet jackets	Table III (hands)	1.90	no
deet jackets/deet hoods	Table III (face)	0.73	no
THFO jackets/deet hoods	Table III (face)	0.06	no

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In this report, the concept of using wide-mesh jackets treated with an insecticide rather than a "space" repellent compound for protection against biting flies is examined. This concept, first studied by the USDA Laboratory at Gainesville, Florida, is based on the hypothesis that reduction in the insect population in the vicinity of a jacket through insecticidal action would be sufficient to provide effective personal protection for the wearer.

Small field tests were carried out at Canadian Forces Base Petawawa to compare the effectiveness of jackets treated with permethrin insecticide, a rapid insect-knockdown compound, the standard repellent N,N-diethyl-m-toluamide (deet), and the experimental repellent tetrahydrofurfuryl octanoate. The ability of repellent-treated wide-mesh hoods to provide facial protection against mosquitoes and blackflies was also investigated.

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KEY WORDS

Field Tests
Insect Control
Insect Repellents
Insecticides
Diptera
Wide-Mesh Jackets
Wide-Mesh Hoods

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